

**REMARKS**

Claims 1, 3, 11-13, 17 and 18 have been amended; claims 1, 3-13 and 15-25 are pending.

Applicants respectfully submit that this amendment is in full compliance with Rule 1.116 as it raises no new issues and does not increase the number of pending claims. Applicants respectfully submit that no new issues are raised by the amendments to claims 1 and 13 because the Patent Office essentially ignored the limitation added in the previous amendment that recites “performing an annealing process to convert the concave top surface of the copper wiring to a convex top surface.” The Patent Office maintained the anticipation rejection based upon U.S. Patent No. 6, 387,806 (“Wang”) despite the fact that this limitation was added to independent claims 1 and 13. Further, on pages 2 and 3 of the “final” office action, the Patent Office merely repeated the original rejection based upon Wang despite the fact that Wang does not show any convex top surface configuration on its copper wiring.

Accordingly, it would be unfair to the Applicants if entry of this amendment after final was refused. Wang in no way teaches or suggests the claimed convex surface added to the claim in the amendment dated November 8, 2004. Thus, the anticipation rejection based upon Wang in the final rejection is not only improper, but fails to adequately address the claim amendments made in the paper filed on November 8, 2004.

Turning to the rejections based upon the prior art, the Patent Office rejects claims 1, 7, 13, 19, 21-22 and 24 under 35 U.S.C. § 102(b) as being anticipated by Wang. Applicant respectfully submits that this rejection is improper for the following reasons.

At the outset, under MPEP § 2131,

[t]o anticipate a claim, the reference must teach every element of the claim. A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference.

*Citing, Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).*

Wang simply does not teach or suggest every claim element of independent claims 1 and 13. Specifically, independent claims 1 and 13 require the formation of a copper wiring that includes the CMP treatment of a copper layer to such an extent that, initially, the

copper layer has a concave surface from a top view thereof and that the lower most portion of the concave surface dips below a top surface of the interlayer insulating layer.

Then, as clearly recited in claims 1 and 13, this concave top surface of the copper layer is converted to a convex top surface using an anneal process. Claims 1 and 13 also recite that the side edges of the concave configuration are disposed below the upper surface of the interlayer insulating layer 22 or 32 as shown in Figs. 2B and 3B. This process step is common to both independent claims 1 and 13. Then, either a copper anti-diffusion insulating film or a copper anti-diffusion conductive film is formed *on top of the convex surface*.

Wang does not teach or suggest this process. The Patent Office relies upon Fig. 14 of Wang because it illustrates an arguably concave recess 228 that is achieved by a "polished down" process. See Wang at column 9, line 16. However, Wang then fills that recess with a copper alloy 232 as shown in Fig. 15.

At no time does Wang teach or suggest an annealing process to convert the recess or concave surface 228 into a convex surface as shown in Figs. 2B or 3B of the present application. In fact, by filling in the recess 228 with the copper alloy 232, Wang fails entirely to avoid the problem of electro-migration and stress migration at a junction of the copper wiring 244 and the encapsulating film 222 (see Fig. 19 of Wang) as explained in connection with Fig. 1 of the present application.

The Patent Office, at page 8 of the final office action, seems to allege that Wang teaches making the alloy fill layer 232 convex. However, this is not taught or suggested by Figs. 14 or 15 of Wang or column 9 of Wang. Wang in no way teaches or suggests making any metal wiring have a convex surface.

Further, Wang deposits a second copper alloy 232 in the concave surface 228. Claims 1 and 13 clearly recite that a copper anti-diffusion insulating film or a copper anti-diffusion conductive film is deposited on the convex top surface of the copper wiring. Wang in no way teaches or suggests the depositing or either an insulating film or a conductive film on a convex copper wiring surface. And, clearly, Wang in no way teaches or suggests any convex surface having side edges disposed below an upper surface of the insulating layer 204.

Therefore, because Wang does not teach or suggest every claim element of either independent claims 1 or 13, Wang cannot serve as an anticipating reference for any pending claim.

Next, the office action rejects claims 13, 15, 19, 21, 23 and 25 under 35 U.S.C. §102(e) as allegedly being anticipated by U.S. Publication No. 2003/0109129 ("Saito"). Applicant respectfully submits that this rejection is improper for the following reasons.

The Patent Office appears to be relying upon Figs. 3-7 of Saito. While Fig. 5 discloses a film M1c, M1b with a concave upper surface, the similarities between Saito and independent claim 13 end there. Saito in no way teaches or suggests an annealing of the structure with a concave copper surface M1c to convert it to a copper structure with a convex surface. Fig. 6 of Saito clearly shows the deposition of the anti-diffusion layer CM1 on top of the concave surface in contrast to claim 13 which recites the deposition of an anti-diffusion layer on a convex surface with side edges below the top surface or the interlayer insulating layer. Saito does not come close to teaching or suggesting the deposition of any anti-diffusion film on a copper structure having a convex surface. Because Saito does not teach or suggest this convex surface, Saito provides no solution to the problem of electro-migration and stress migration illustrated in Fig. 1 of the present application and solved by the methods of independent claims 1 and 13.

Therefore, because Saito does not even come close to reciting all of the process steps of independent claim 13, applicant respectfully submits that the anticipation rejections of claims 13, 15, 19, 21, 23 and 25 based on Saito are improper and should be withdrawn.

Again, like the rejection based on Wang, Applicants take the position that the claims as amended on November 8, 2004 distinguish over Saito as Saito does not teach or suggest any convex surface or the deposition of an anti-diffusion layer on a convex surface of a copper wiring. The claim limitations added to claim 13 on November 8, 2004 seem to have been ignored by the Patent Office with the exception of page 8, paragraph 21 which states that the annealing of the tungsten layer CM1 in Fig. 6 of Saito would result in the conversion of the copper plug from being concave to convex. This is mere conjecture. The Saito figures do not teach or suggest this, nor does the Saito specification. All of the Saito figures clearly disclose a convex copper plug throughout the processes. If a concave structure were created,

Saito would have disclosed as much. Accordingly, the anticipation rejection as set forth in the final office action is improper and should be withdrawn.

Next, the office action rejects claims 16-18, 20, 22 and 24 under 35 U.S.C. § 103 as being unpatentable over Saito. Applicant respectfully submits that this rejection is improper for the following reasons.

At the outset, under MPEP §§ 2142 and 2143,

[t]o establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure.

*Citing, In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991); *see also* MPEP § 2143-§ 2143.03 for decisions pertinent to each of these criteria.

As established above, Saito does not teach or suggest all of the process steps of independent claim 13. Saito does not teach the formation of a concave copper structure *followed* by an annealing step which converts the concave copper structure to a convex copper structure and, the deposition of an anti-diffusion layer *on the convex copper structure* which provides a solution to the electro-migration and stress migration problems discussed in the background section of the present application. Thus, the November 8, 2004 version and the current version of claim 13 are allowable over Saito.

Further, Saito in no way teaches or suggests the formation of a convex structure with side edges disposed below an upper surface of its insulating layer 22b. Applicants are bewildered by the Patent Office's position that the annealing taught by Saito would convert its clearly shown concave structure into a convex structure. If this were true, and the Saito reference actually taught such a conversion of a concave structure to a convex structure, Saito would have shown such a structure in his drawings or provided an explanation in his specification. Saito did neither and, therefore, Saito fails to teach or suggest claim 13 as amended on November 8, 2004, or claims 13 as amended here.

Because Saito fails entirely to teach or suggest all of the claim limitations and further because there is no teaching or suggestion in Saito that would lead one skilled in the art to make the necessary changes in Saito to arrive at all of the claim limitations of independent claim 13, Saito fails to establish a *prima facie* case of obviousness of independent claim 13.

Therefore, applicant respectfully submits that all obviousness rejections based upon Saito fail to meet the criteria of §§ 2142 and 2143, are improper and must be withdrawn.

Finally, the office action rejects claims 3-6, 8-12, 15-18, 20, 23 and 25 under 35 U.S.C. § 103 as being unpatentable over Wang in combination with U.S. Publication No. 2003/0114000 ("Noguchi"). Applicant respectfully submits that this rejection is improper for the following reasons.

The deficiencies of Wang are set forth above. Wang does not teach or suggest the formation of a concave copper structure *followed by an annealing step which converts the concave structure into a convex copper structure followed by the deposition of an anti-diffusion film on the convex copper structure*. Therefore, Wang is clearly deficient as a base reference.

Noguchi is only cited for the proposition that it teaches cleaning processes, an annealing process and a plasma process. However, Noguchi is not cited for, nor does it teach the formation of a concave copper structure, the annealing of that concave structure to a convex structure and a deposition of an anti-diffusion film on a convex structure.

Noguchi does teach annealing which results in a slightly convex structure as shown in Fig. 10. However, Noguchi does not begin with a concave structure. Further, Noguchi does not teach or suggest a convex structure with side edges disposed below an upper surface of the insulating film 11b as clearly recited in independent claims 1 and 13. Neither does Wang. The Wang concave structure shown in Fig. 14 is then filled in with copper oxide material 232. Thus, there is no heat treatment of Wang's concave structure 228 to convert it to a convex structure. Wang, instead, teaches that the recess 228 should be filled with a second copper alloy 232. See Wang at column 9, lines 35-37. Then, Wang teaches a heat treatment that results in the formation of an encapsulating material 222. See column 9, lines 53-67. However, in contrast to the assertions made in the final office action, Wang in no way teaches or suggests converting its concave structure to a convex structure. The only

convex structure is the encapsulating material 222 in Fig. 19 which is not deposited on a concave structure.

Thus, Wang does not teach or suggest the formation of a concave structure and converting that concave structure to a convex structure with side edges disposed below an upper surface of the insulating layer 204. . Wang instead fills the recess 228 with additional alloy 232. Noguchi, on the other hand, begins with a planar structure (see Fig. 10) and anneals that structure from its planar configuration. Thus, Noguchi does not teach or suggest the heat treatment of any concave structure, but only the heat treatment of planar structures.

Noguchi, then teaches farther away from claim 13 by requiring an insulating layer 15b, which is not equivalent to the anti-diffusion conductive film recited in claim 13.

Therefore, there is no combination of Wang and Noguchi that teaches or suggests the formation of a concave copper structure, the annealing of that concave copper structure to convert it to a convex copper structure followed by the deposition of an anti-diffusion conductive film on the convex structure. Accordingly, no combination of Wang and Noguchi teaches or suggests all of the claim limitations of independent claims 1 and 13 and therefore applicant respectfully submits that no combination of these two references establishes a *prima facie* case of obviousness under §§ 2142 or 2143.

Therefore, applicant respectfully submits that the obviousness rejections based upon Wang and Noguchi are improper and should be withdrawn.

With all rejections having been addressed and traversed, applicant respectfully submits that this application is in a condition for allowance and an early action so indicating is respectfully requested.

The Commissioner is authorized to charge any fee deficiency required by this paper, or credit any overpayment, to Deposit Account No. 13-2855.

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Respectfully submitted,

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